

HexSim

**Its a model that's been around
in some form
for about 15 years now...**

- Circa 1992**
Original version was a graduate project
- 1995 - 2000**
Focused mostly on landscape structure
- 2001 - Present**
Expanded to multiple species & stressors

What is HexSim

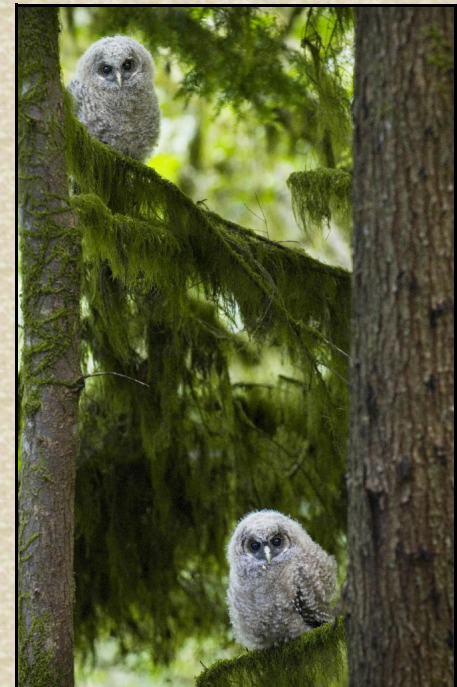
A SEPM that attempts to balance realism, generality, and parsimony

- ▣ Spatially-explicit**
- ▣ Individual-based (with group dynamics)**
- ▣ Life cycle is user-defined**
- ▣ Individuals can be unique**
- ▣ Populations and stressors can interact**

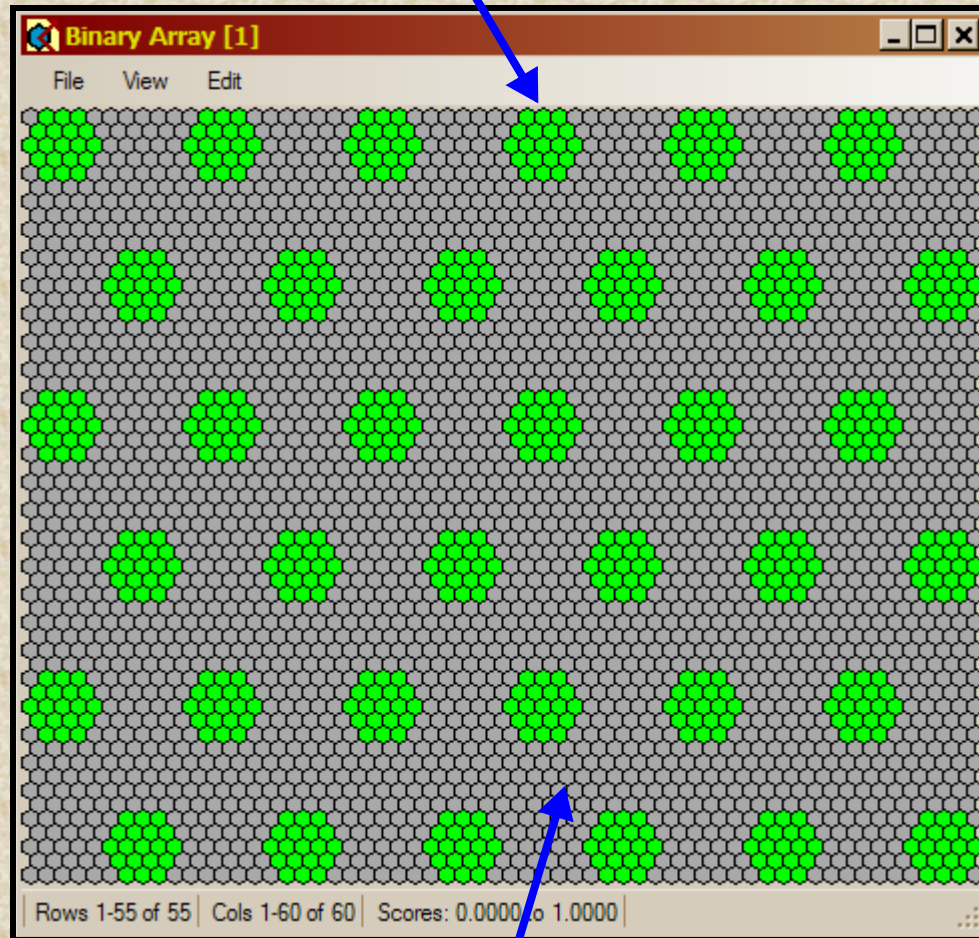
An Example

Northern Spotted Owl (*Strix occidentalis caurina*)

- ➔ How will spatial pattern influence population viability?
- ➔ Combine realistic owl demographics with an artificial landscape



Habitat patches are all equal



Hypothetical
Spotted Owl
Reserve Design

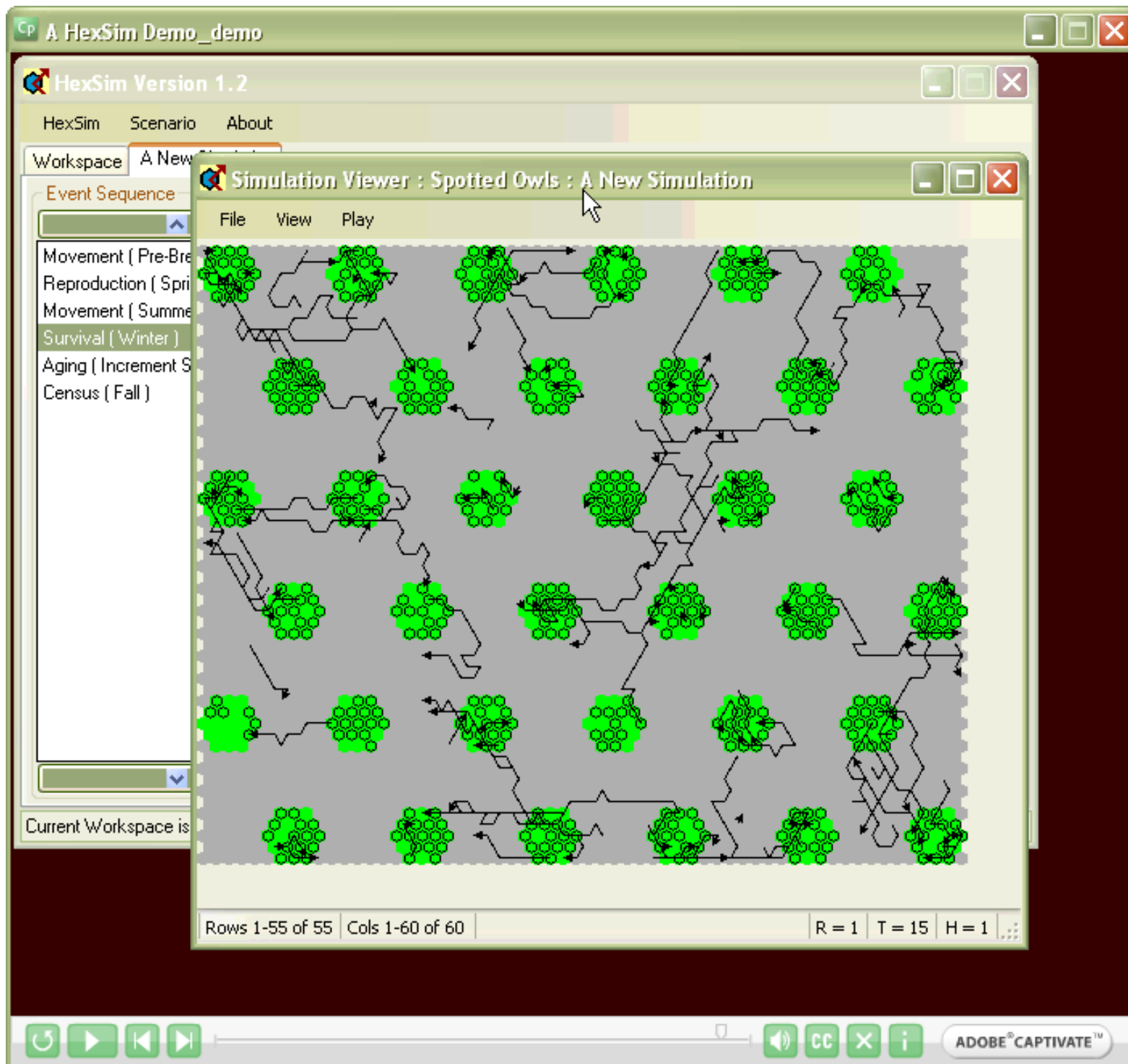
This regular array
of spotted owl
habitat clusters
illustrates a
specific reserve
design concept

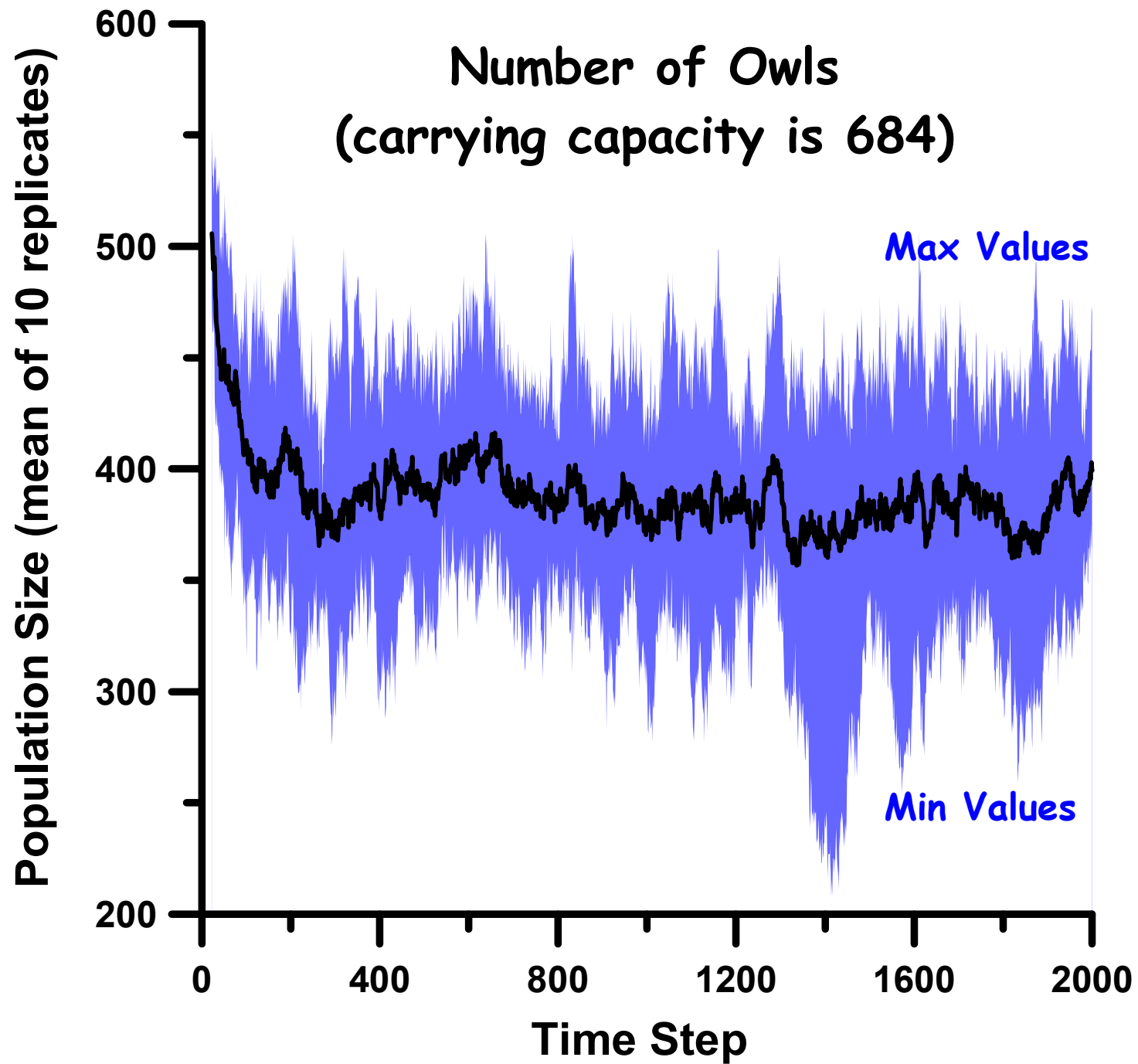
Owls cannot survive in the matrix

How Will The Owls Do ??

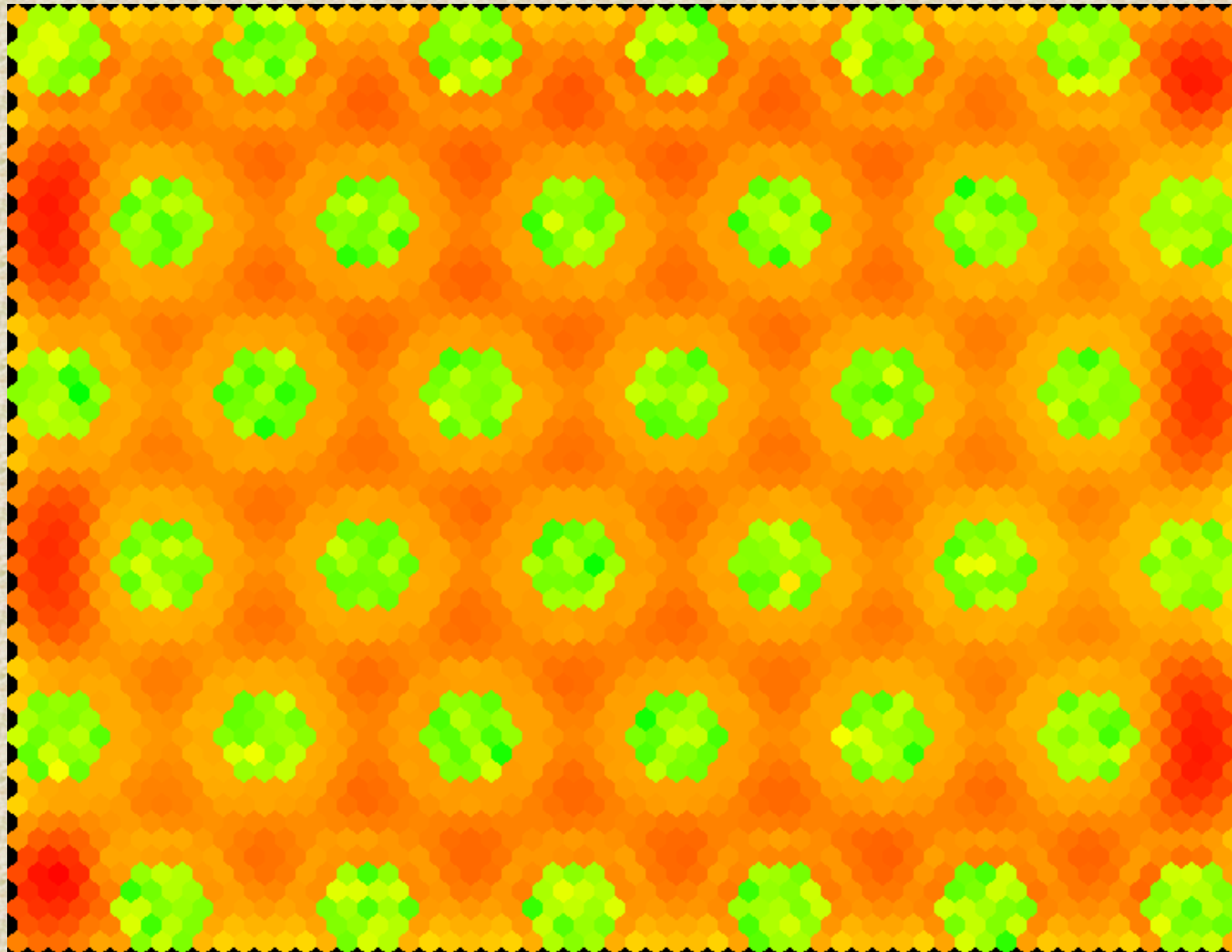
Some data indicate that Lambda
is slightly greater than 1.0

- Thus the population *should* remain stable
- But what about dispersal success rates,
and the impact of non-breeding floaters ?





Observed Owl Productivity (births - deaths)



Highest
Productivity



Lowest
Productivity

How Was Owl Performance ??

[Final 1000 Years, Averaged Over 10 Replicates]

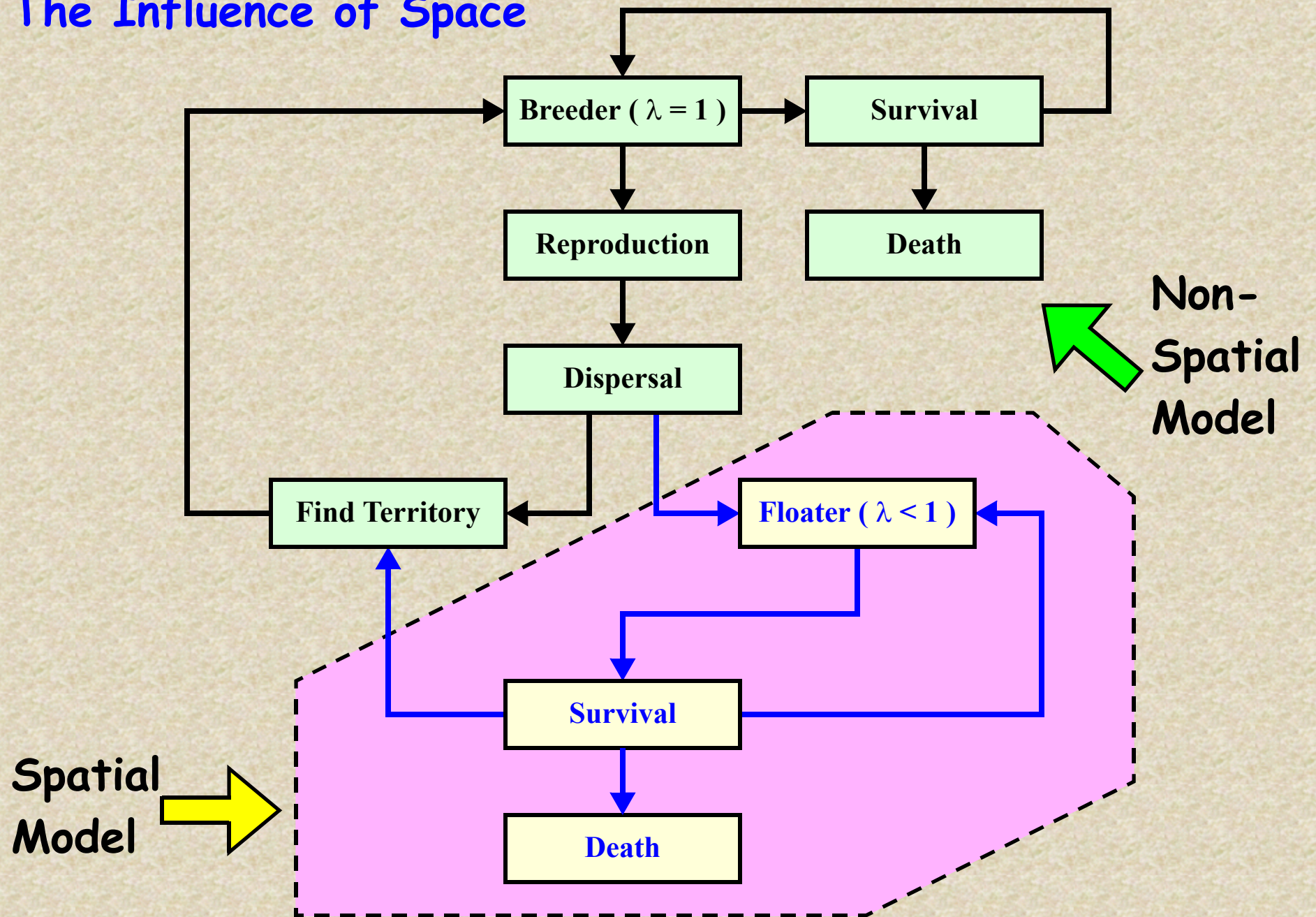
Input Matrix =
$$\begin{bmatrix} 0.078 & 0.192 & 0.348 & 0.348 \\ 0.333 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.760 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.850 & 0.920 \end{bmatrix} \quad \lambda = 1.013$$

Output Matrix =
$$\begin{bmatrix} 0.077 & 0.192 & 0.349 & 0.348 \\ 0.290 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.756 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.849 & 0.920 \end{bmatrix} \quad \lambda = 1.001$$

Lowered Survival
Due To Dispersal
Success (ie. Space)

Carrying Capacity = 684
Mean Population Size = 381
Occupancy Rate = 56%

The Influence of Space



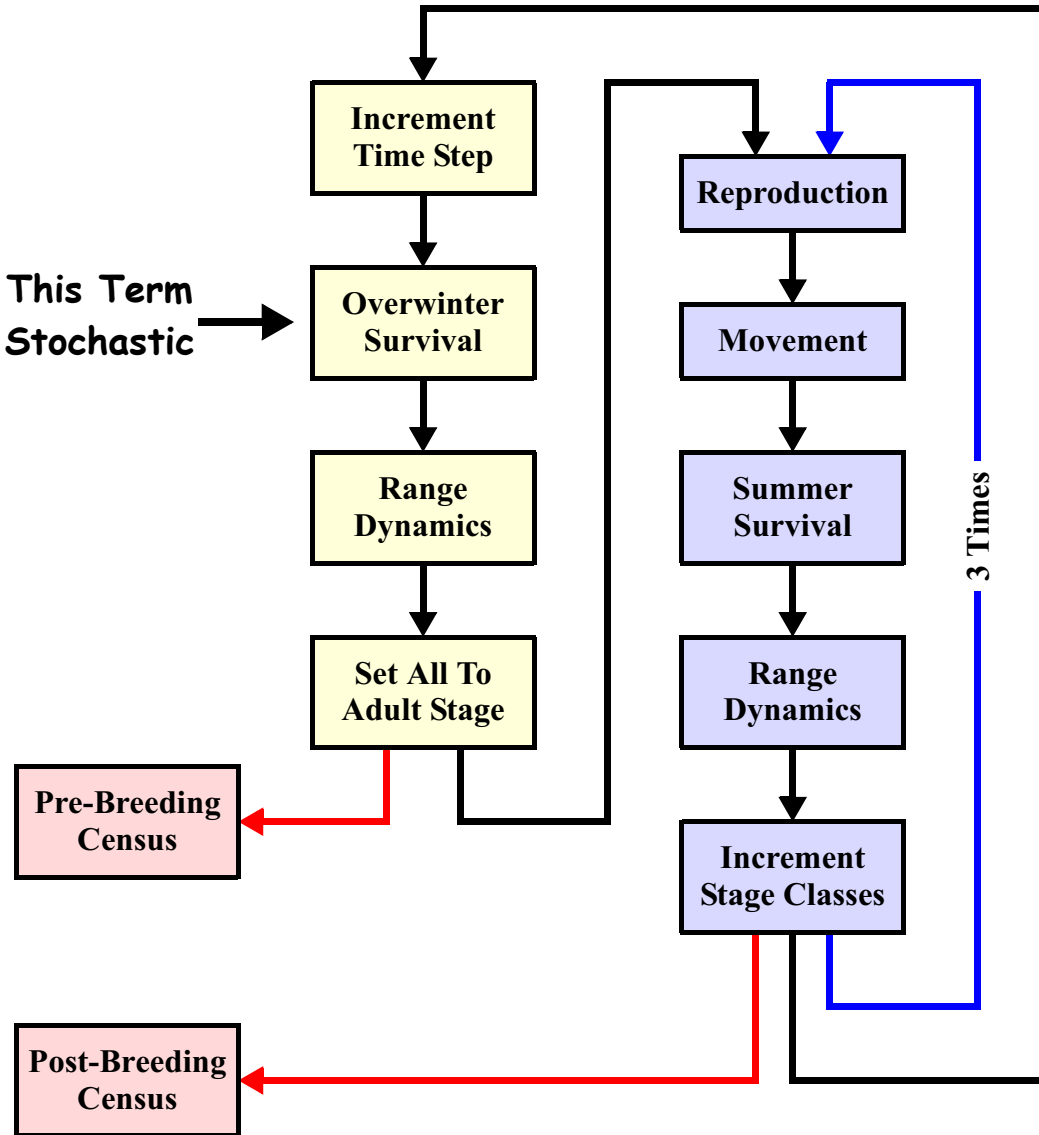
A Second Example

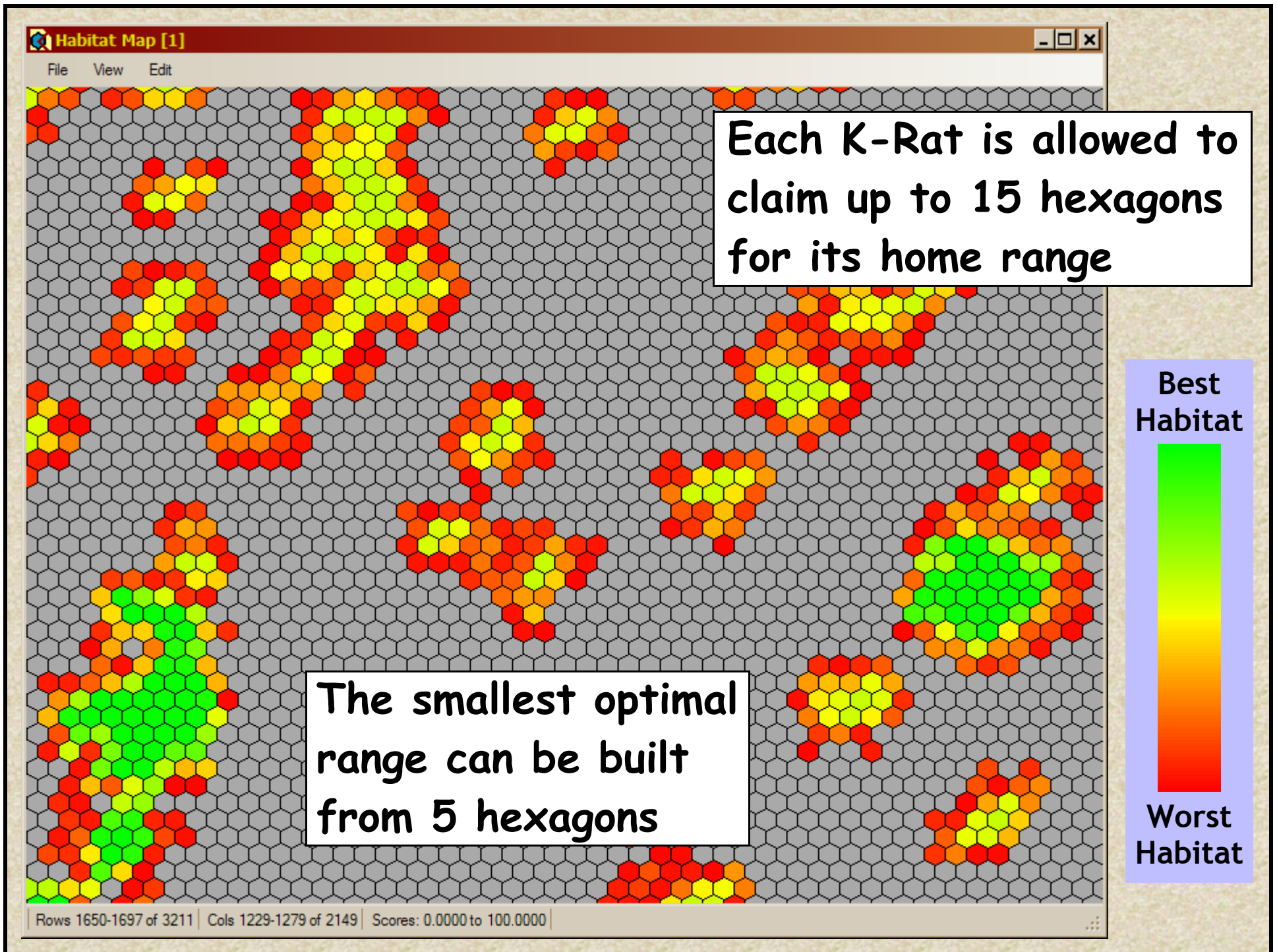
Ord's Kangaroo Rat (*Dipodomys ordii*)

- Listed as an endangered species in Alberta, Canada
- Population is declining, and the rate of decline is increasing
- HexSim is being used to develop a PVA for the species

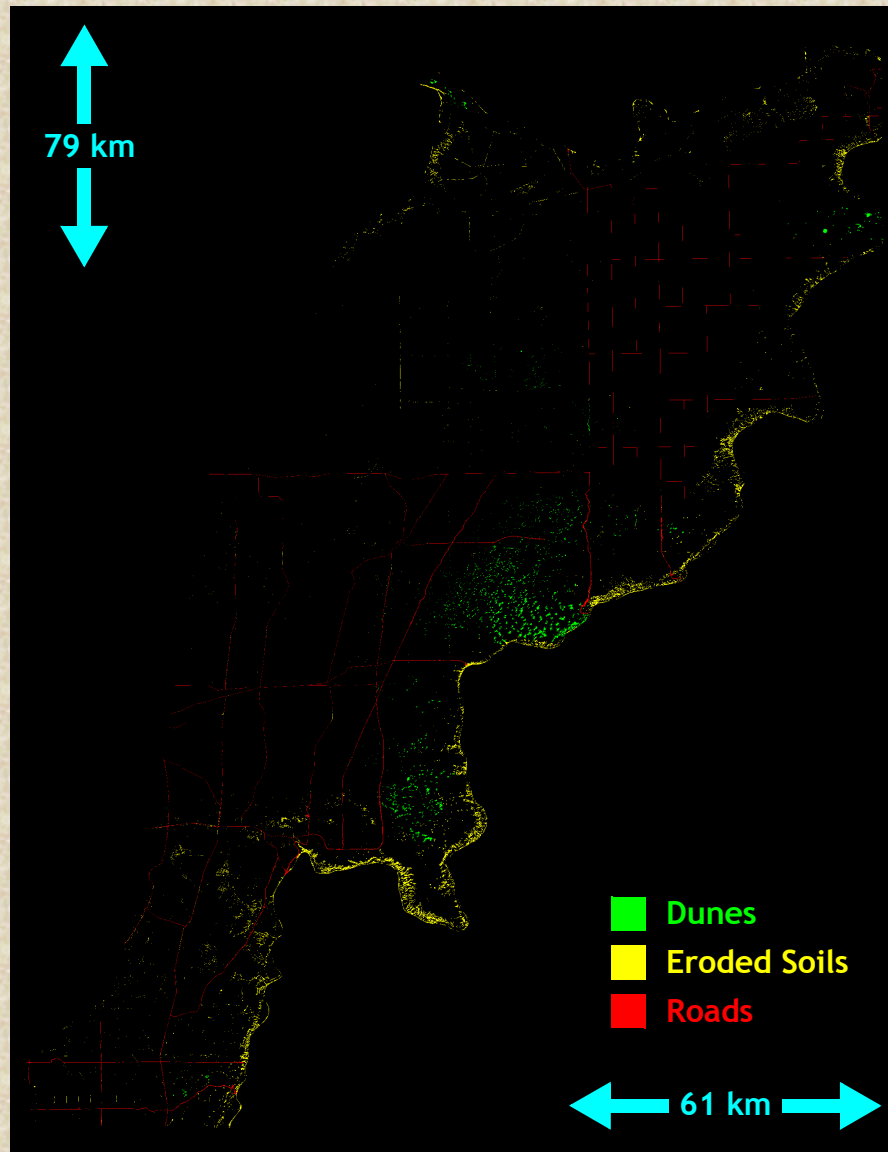


Kangaroo Rat Life Cycle Implemented in HexSim

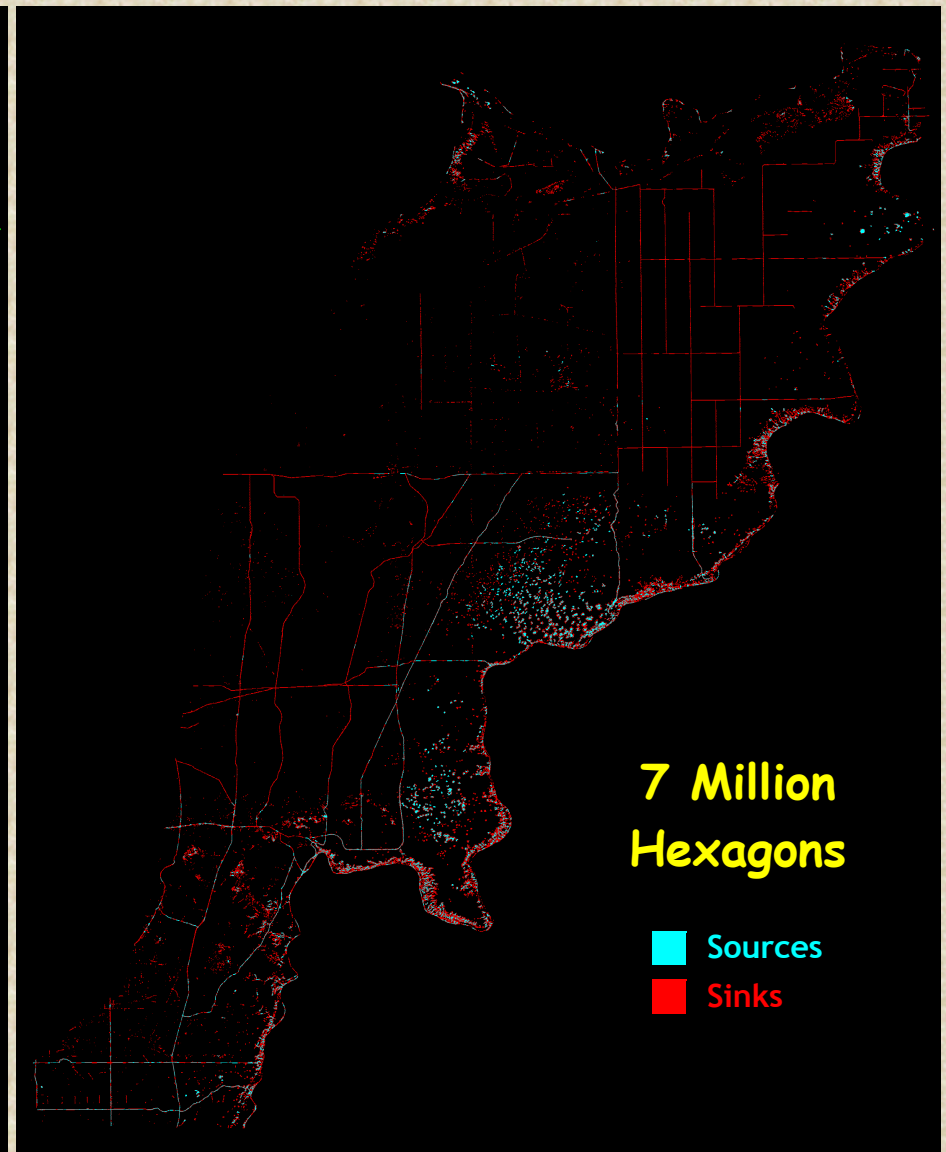


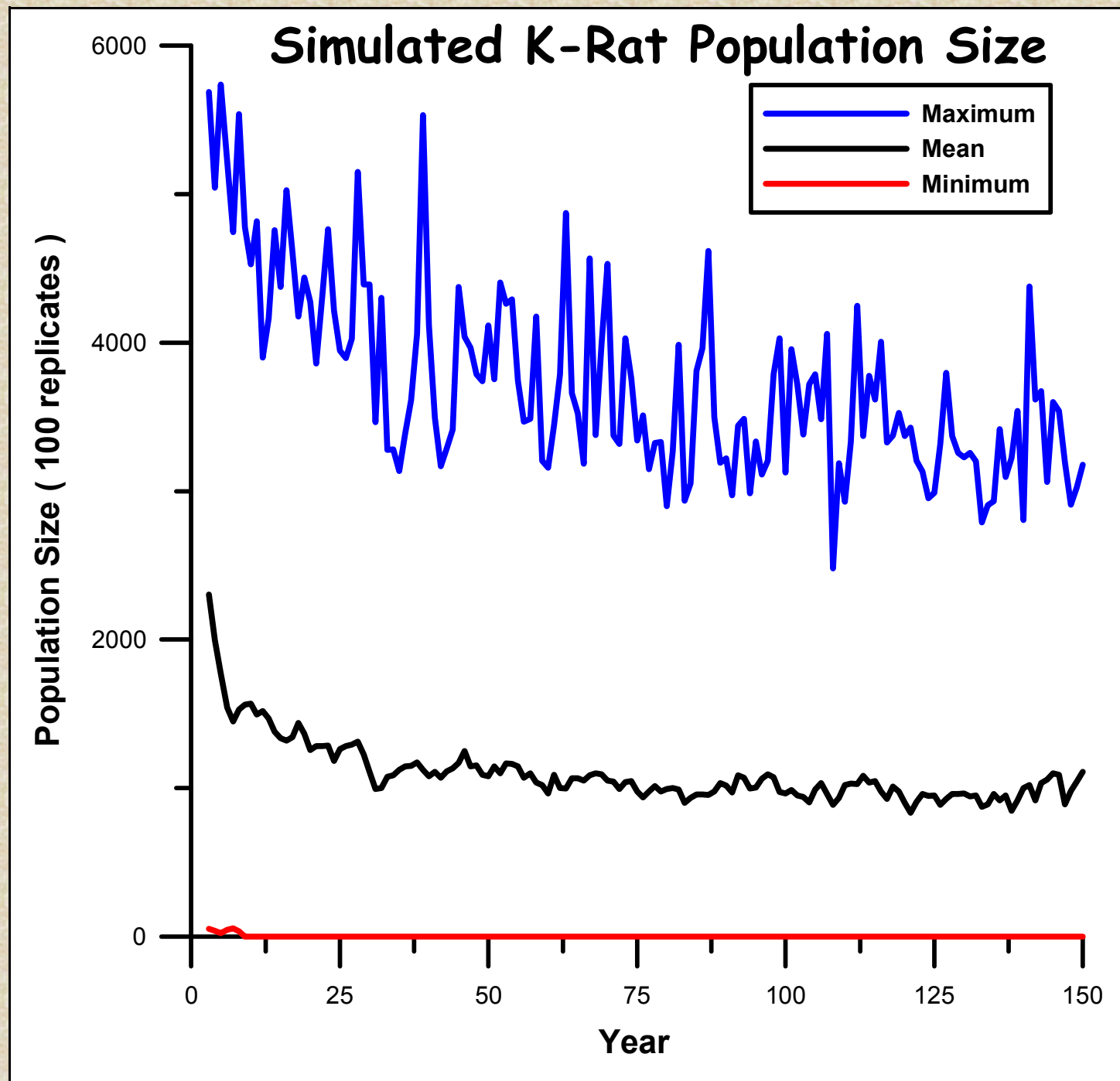


Raster Habitat Map (Model Input)

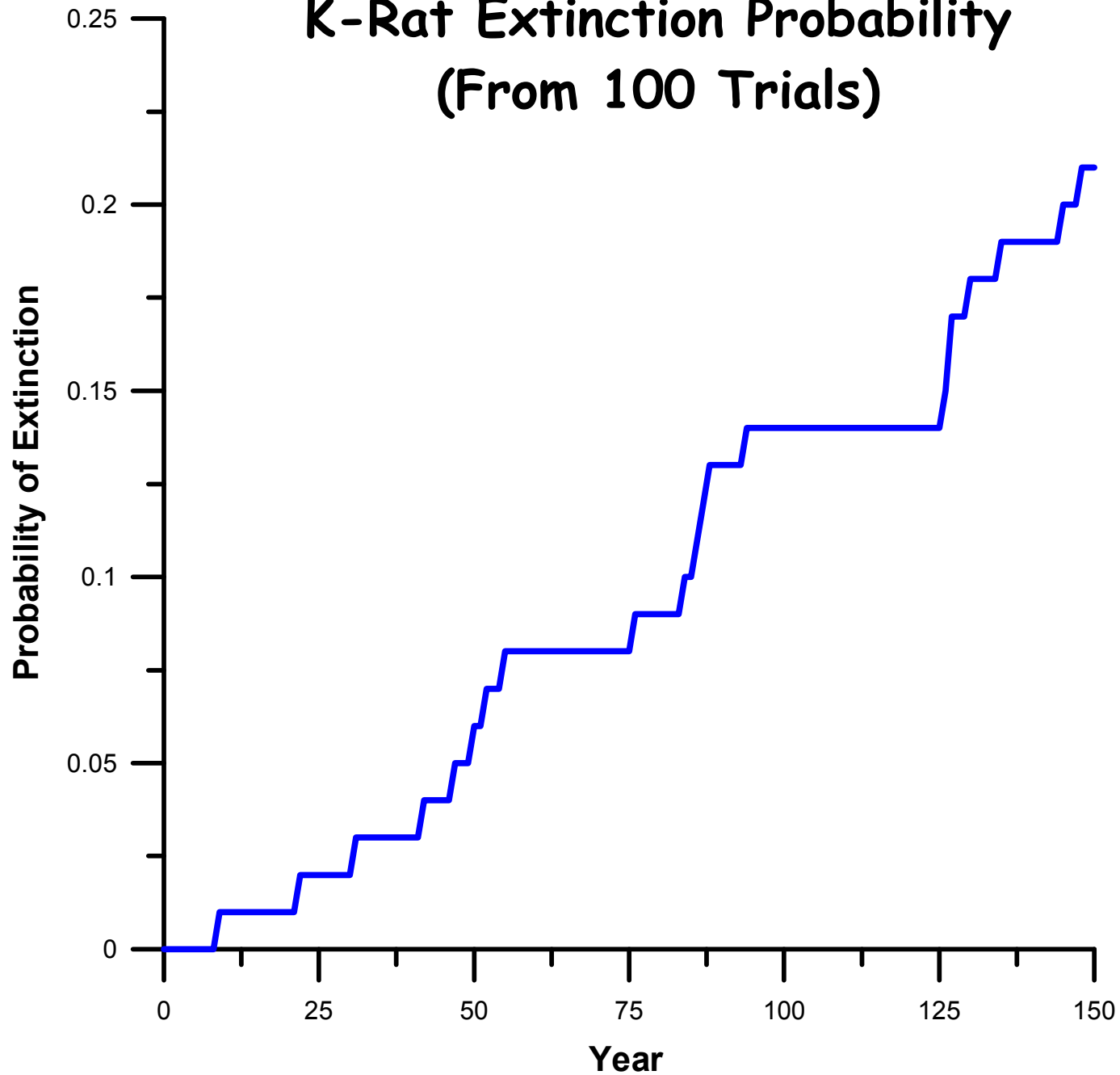


K-Rat Productivity (Model Output)

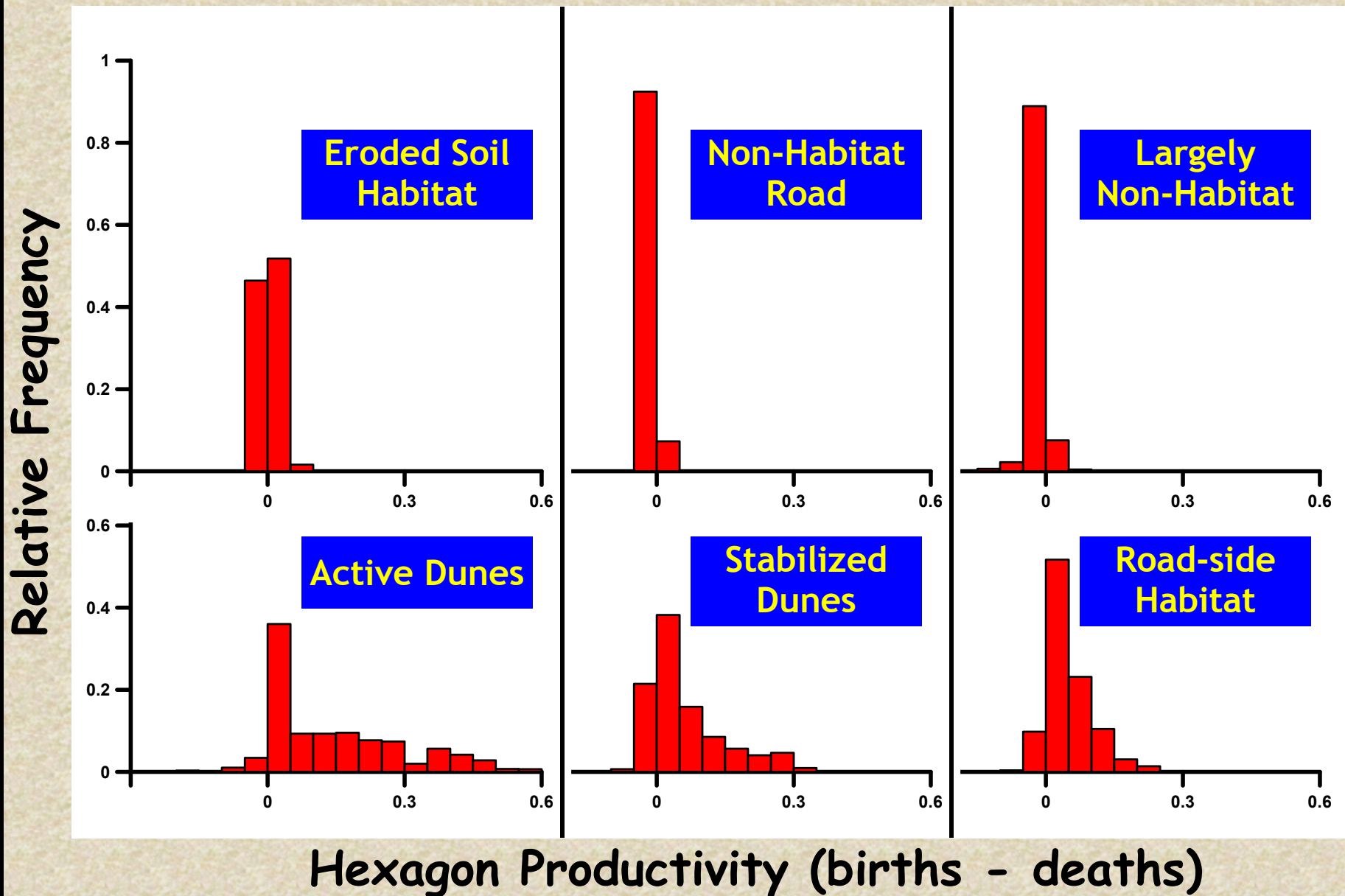




K-Rat Extinction Probability (From 100 Trials)



K-Rat Productivity by Hexagon Habitat Mode



**Results From A Small Removal Experiment
(10 Replicates, 200 Years, Subset of Krat Landscape)**

	Sinks	Poor Quality Sources	Good Quality Sources
Number Hexagons	1953	1008	227
Population Dropped By	15%	17%	20%
Hectares To Remove For The Population To Drop By 1%	9.1	4.2	0.8

Concluding Thoughts

www.hexsim.net
www.epa.gov/hexsim

- One tool = multiple applications
- Data requirements are flexible
- Realism can be added iteratively
- Works with multiple species & stressors
- Also includes barriers, traits, etc.